Set forth below is a clean copy of the portion of the specification that has been amended. Applicants request the clean copy of the portion of the specification be entered.

CLEAN COPY OF THE PORTION OF THE SPECIFICATION AMENDED IN THE PATENT APPLICATION

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The present invention relates to an output choke for a D.C. arc welder which solved the problems of weight, cost and welding inconsistencies experienced by a large choke having a fixed air gap or a smaller choke having a stepped air gap. In accordance with the invention, the output choke for the D.C. arc welder comprises a high permeability core with an area having a cross sectional shape with two spaced edges and an air gap wherein the air gap has a gradually converging width for at least a portion of the distance between the two edges. Thus, the air gap gradually increases from the edges. In the preferred embodiment, the air gap is a diamond shape, gradually increasing from the edges to the center portion of the core. This diamond core technology for the output choke of a D.C. welder produces an inductance in the output circuit which gradually varies over the current range in an inverse relationship with the weld current. As the welding current increases, the inductance decreases in a continuous manner without any discontinuity or steps. Thus, the weld current is never at a saturation point for the output choke or operating on the saturation knee. There is no oscillation of the power to the weld. This invention produces a robust welder which can handle changes of up to 5-10 volts with arc length changes without causing instability of the arc. Thus, the choke provides current control over a wide range of weld currents without oscillating or without the need for a large output choke.

NE Referring now to the drawings, wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting same, FIGURE 1 shows a D.C. electric arc welder 10 capable of creating a welding current of at least about 50 amperes and up to 200-1,000 amperes. Power source 12, shown as a single phase line voltage, is directed through transformer 14 to rectifier 16. Of course, the rectifier could be driven by a three phase power source to create a D.C. voltage. In accordance with standard practice, a capacitor 20 having a size of about 20 K-150 K micro farads is charged by inductor 22 having a size of approximately 20 mH. Rectifier 16 charges capacitor 20 through inductor 22, which inductor may be replaced by inductance of the transformer. Output voltage from rectifier 16 at terminals 24, 26 is the voltage across capacitor 20 that maintains a voltage across arc gap *a* between electrode 30 from a wire feeder 32 and workpiece 34. To maintain an even flow of current across arc *a*, a relatively large output choke 50 is provided in the output circuit between capacitor 20 and gap or arc *a*. The invention involves the construction and operation of current control output choke 50, as best shown in FIGURE 6. In the past, the output choke was a large choke as schematically shown in FIGURE 2 wherein choke 100 has a high dependability core 102 with an air gap g defined between two facing surfaces 104, 106. The high currents demand large wires for winding 110. To obtain high inductance, the number of turns is high. To prevent saturation the cross section of core 102 is large. Thus, choke 100 is large, heavy and expensive. By changing the width of gap g between surfaces 104, 106, core 102 is saturated by high weld currents in winding 110 by saturation curves, as shown in the graphs of FIGURE 3. When air gap g is relatively small for a given choke, a high inductance is created; however, at low weld currents the core is saturated. This is shown in saturation curve 120. As the width of gap g is increased, the inductance is decreased and saturation

NE current is increased. This relationship of an increased gap size is indicated by saturation curves 122, 124 and 126. Each of the saturation curves has saturation knees or points 120a, 122a, 124a and 126a, respectively. When operating arc welder 10 with a fixed air gap, as shown in FIGURE 2, a saturation curve must be selected to accommodate the desired welding currents. To produce both a high inductance and a large current range, the windings 110 must be increased and the core size must be increased. This drastically increases the size and weight of the choke. By decreasing the weight and size of the choke the saturation curve has a reduced saturation current which causes erratic operation of the D.C. welder. In order to correct the problems associated with an output choke having a fixed gap for controlling the current in the output circuit of a D.C. arc welder, it has been suggested to use a choke as shown schematically in FIGURE 4. Choke 200 includes a high permeability core 202 having an air gap 210. In this choke, the air gap is stepped with a large gap 212 and a small gap 214 created by adding a small pole piece 216. When currents exceeding 100-500 amperes are passed through winding 220, the inductance follows a two part saturation curve as shown in FIGURE 5. This non-linear curve includes a first portion 230 employed until gap 214 is saturated and then a second portion 232 employed until larger gap 212 is saturated. These two sections create an effective current-inductance relationship illustrated by dashed line 240. This inverse current-inductance is extremely beneficial in electric arc welding. The two part curve accommodates both low current and high current operation. However, there is an abrupt saturation knee 232a causing an inflection point 242. As the arc welder operates along line 240, inflection point 242 causes oscillation as the wire feed speed is changed or the arc length or arc voltage is changed. Thus, there is a hunting action in the area of the inflection point 242 which reduces the effectiveness of the suggested stepped air gap approach shown schematically in FIGURE 4.

Choke 50 of FIGURE 1 incorporates the preferred embodiment of the present invention as illustrated in FIGURES 6-8. Core 52 of high permeability material has a cross section large enough to prevent saturation at over 50 amperes and preferably over 100-500 amperes. Facing surfaces 54, 56 of core 52 are between spaced edges 54a, 54b and 56a, 56b. The respective transversely spaced edges face each other and provide a relatively small air gap, if any. The center area 58 between surfaces 54, 56 constitutes a large air gap. This diamond shape air gap is between the spaced edges of faces 54, 56 and is defined by portions 54c, 54d of surface 54 and 56c, 56d of surface 56. These portions diverge together from a maximum air gap at apex 54e and apex 56e of the diamond shaped air gap. A winding 60, having a size to carry the weld current and a turn number to obtain the desired inductance, conducts the welding current around core 52. By using the diamond shaped air gap as shown in FIGURE 6, with the selected core size and turn number, current-inductance curve 70 in FIGURE 7 is obtained. Curve 70 represents an ideal current-inductance relationship for electric arc welding when the current progresses from 20 amperes to a high level exceeding about 200 amperes and often exceeding 500-1,000 amperes. As shown in FIGURE 8, the small air gap at edges 54a, 56a and 54b, 56b tends to saturate at low currents. As the current increases, the diamond shaped air gap in choke 50 cannot saturate. At high levels the choke attempts to saturate an extremely large air gap. As indicated by the arrows, the saturation of the core by flux through the diamond shaped air gap would saturate the smaller gaps at position a, but not progressing upward from points b, c, d. The apex of the diamond shaped air gap is selected to prevent saturation even at maximum weld current. Thus, there is a straight line relationship between current and inductance, which relationship is gradual and continuous by the use of the diamond shaped air gap.

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In practice, choke 50 has a core 52c as illustrated in FIGURE 14. A diamond shaped symmetrical air gap 400 is provided between pole pieces 402, 404 with the abutting edge portions 406, 408 touching each other to define the intermediate air gap 400 with small gap portions 410, 412 gradually increasing to a large gap portion 414. Pole pieces 402, 404 are joined by a strap 420 using appropriate pins 422, 424. Air gap 400 is a diamond shaped air gap, which air gap is large at the apex or center and decreases toward both edges of the core. This diamond shaped air gap provides a generally straight line, inversely proportional relationship between current and inductance, which relationship is optimum for electric arc welding. A low permeability potting material can fill air gap 400 when the choke is packaged for use in the field.